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(54) HEAT TREATMENT METHOD OF POLYESTER BASED COMPOSITE FILAMENT

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CLAIM

A method for manufacturing polyester based composite filament yarn with well deviated phases of coils characterized by the fact that when the bulky filament yarn with 3-dimensional spiral structure having coiling manifested after drawing of polyester based latent coiling composite fibers to display the latent coiling property is manufactured, after drawing of the latent coiling composite fibers and before coiling manifestation treatment, heat treatment is performed at a temperature in the range of 100-180°C and with tension of the yarn kept in the range of 0.01-0.05 g/d, followed by manifestation of coiling under a low tension.

DETAILED EXPLANATION OF THE INVENTION

This invention pertains to a method for drawing and heat treatment of multifilament of thermoplastic synthetic fibers having latent coiling property. In particular, this invention pertains to a heat treatment method of composite fibers characterized by the fact that after polyester based composite filaments are drawn using the conventional method, relaxing heat treatment is performed by means of heating rollers or heating plates.

It is well known that when polymers having different properties, such as polymers with different shrinkage properties, are bonded with each other, one as the back and the other as the front, on the cross section perpendicular to the fiber axis, latent distortion is displayed. When heat treatment is performed in the relaxed state, coiling takes place.

Latent coiling yarns are usually used as processed yarns for cloths. For this purpose, the various filaments that form the yarn should not form groups. Instead, they should have phases of individual spiral coils or waves deviated from each other uniformly. For this purpose, various methods have been proposed. For example, Japanese Kokoku Patent Application Nos. Sho 42[1967]-6011, Sho 45[1970]-58745 and Sho 46[1971]-15752 described a method for rubbing yarns by means of contact with a knife edge. However, in this conventional method, the yarn characteristics may degrade. Also, it is hard to realize sufficiently uniform deviation in phase. If deviation in phase is insufficient, in the later steps of operation, bulging of the coiling yarns due to relaxation heat treatment becomes insufficient. When such yarns are used to form knitware or woven fabric, the overall fabric becomes thin and without bulging. Also, as irregular coils form groups, defective spots appear on the surface of the knitware or woven fabric. As a result, the commercial value of the product degrades.

The purpose of this invention is to provide a method for forming coiling yarns with large apparent volume due to coils having their phases deviated uniformly, that is, with coils on each filament not in agreement with those on the other filaments.

In order to solve the aforementioned problems, the present inventors have performed extensive research on manifestation of coils of the latent coiling composite fibers. As a result of this research work, the following features have been found. When the latent coiling composite fiber is drawn for a prescribed drawing rate using a conventional drawing machine, when the fiber is set free of tension, coils take place due to the latent stress. However, for the coil generating state in this case, although certain fine coils are generated right after drawing, the coils are nevertheless grouped with uniform phase distribution. When relaxation heat treatment is carried as it is, fine coil crimps with same coil phase are manifested, and only a yarn with poor bulkiness can be obtained. Also, after a period of several hours or several days as the drawn yarn is wound up on a bobbin or a pirn, rough crimps appear on the entirety. When the coils are

manifested, deviation in phase of coiling can take place easily, and a bulky filament can be obtained. This fact indicates that for the latent coiling composite fiber after drawing, the properties vary over time. In order to obtain good coiling yarns in a prescribed state, one has to perform coiling manifestation treatment after a prescribed setting time. As a result, management of the manufacturing process becomes very complicated. Also, in recent processing operation, the aforementioned condition becomes highly unfavorable to the efforts in simplification, continuous operation and high speed operation. In both the case when coiling manifestation is performed right after drawing so as to reduce man-hours in management of drawn yarns, and the case when the drawn yarns are wound up and set for a while before manifestation of coiling, it is necessary to prepare drawn yarns free of variation over time so as to obtain prescribed coiling manifested yarns. The purpose of this invention is to solve the aforementioned problems of the conventional drawn yarns by providing a method for manufacturing uniform bulky filament yarns with a stable quality by means of manifestation of coiling.

In the following, this invention will be explained in more detail. After polyester based composite fibers are drawn using the conventional drawing method for conventional filaments, heat treatment is performed at a temperature in the range of 100-180°C under a tension in the range of 0.05-0.01 g/d, or preferably in the range of 0.03-0.02 g/d. Then, as described in Japanese Kokoku Patent Application No. Sho 52[1977]-2947, in the relaxation state, coiling manifestation and fixing are performed. When the tension in heat treatment is over 0.05 g/d, the latent coiling property is lost, and, in the later relaxation heat treatment for coiling manifestation, sufficient coiling manifestation cannot be realized. On the other hand, when the tension during heat treatment is lower than 0.01 g/d, "neck" like bundled portions are developed in the yarn after heat treatment and before coiling manifestation. Also, for the filament, sag becomes significant, and it is hard to perform stable treatment. When the heat treatment temperature is lower than 100°C, the heat treatment element as the purpose of this invention becomes weak. Consequently, in the later relaxation heat treatment, deviation of phases of coils in the coiling manifestation operation becomes poor, and bundled coiling takes place. On the other hand, when the temperature is higher than 180°C, heat treatment effect becomes higher, and the latent coiling property is lost. Consequently, even after the coiling manifestation operation, it is still impossible to obtain a bulky fiber. That is, according to this invention, as shown in Figure 9, each filament manifests coiling independently without correlation, and good bulging takes place. In addition, because the phase deviation of coils is good, in the relaxation heat treatment, bulging of the coiling manifested yarn becomes larger. On the other hand, when the method of this invention is not adopted, as shown in Figures 6-7, the overall yarn becomes a uniform wavy shape, and it is hard to have the filaments coiled separately. Also, as there are portions of

bundling for the coils; even in the relaxation heat treatment operation, coiling remains fine and a high bulkiness cannot be realized.

In the following is given an embodiment of this invention.

Figure 1 is a diagram illustrating a common method for embodiment of the method of this invention. Also, the methods shown in Figures 2 and 3 may also be adopted for embodiment of this invention. Figure 3 is a diagram illustrating a method using rollers in special shape, such as tapered shape or stepped shape.

In Figure 1, roller (1) is a yarn feeding roller. A preparatory tension is applied between it and roller (2) so as to ensure a stable yarn path for the running yarn. When drawing is performed on hot pin (3) and hot plate (4), roller (2) may be preheated to ensure uniform drawing. After drawing for a prescribed rate between roller (2) and roller (5), heat treatment is performed under the condition of this invention between roller (5) and roller (7). In this case, by means of hot plate (6), the tension between roller (5) and plate (6) is in the range of 0.01-0.05 g/d. In the process shown in Figure 2, the operation pertaining to roller (8), roller (9), hot pin (10), hot plate (11) and roller (12) is the same as that in Figure 1. However, the yarn tension is kept in the range of 0.01-0.05 g/d between roller (12) and roller (13) while heat treatment is performed by means of hot roller (13). In the process shown in Figure 3, the operation pertaining to roller (14), roller (15), hot pin (16) and hot plate (17) is the same as that shown in Figure 1, while roller (18) is a tapered or stepped heating roller. For example, drawing is performed between (A) in Figure 3(A) and roller (15), and a prescribed heat treatment can be performed between (A) and (B) of Figure 3A.

In the above, we have explained heat treatment of the method in this invention with reference to an example of continuous treatment shown in Figures 1-3. However, the heat treatment operation in this invention may also be embodied independently from drawing as shown in Figure 4. Also, it is possible to perform coiling manifestation continuously after this operation. As far as the method for coiling manifestation is concerned, any of the conventional methods, such as hot plate, hollow heater, hot air blowing type heat treatment device, etc., may be used to realize the purpose of this invention. In the method shown in Figure 4, the filament wound up on a pirn after drawing using a conventional drawing machine is fed to roller (19). While the yarn tension between it and hot plate (20) is kept in the range of 0.01-0.05 g/d, it is pulled with roller (21), and the filament is wound again on a bobbin. Also, as shown in Figure 5, the drawn yarn is fed to roller (22), and, while a tension of 0.01-0.05 g/d is maintained between it and hot plate (23), it is pulled with roller (24), so that coiling is manifested continuously while overfeeding is performed between roller (24) and roller (26) by means of coiling manifestation machine (25). Then, after cooling in between roller (26) and roller (27), it is wound up on bobbin.

According to this invention, polyester is mainly made of a substantially linear polymer derived from dibasic acid and dihydric alcohol. In particular, polyethylene terephthalate is a common type of such polyester. As the acid component, one may make use of adipic acid, sebacic acid, isophthalic acid, ortho-phthalic acid, naphthenic acid, or other dibasic acids and their derivatives, which may be used either alone or as a mixture of several types. On the other hand, as the alcohol component, one may make use of ethylene glycol, propylene glycol, butylene glycol, polymethylene glycol, cyclohexanediol, and other dihydric alcohols, which may be used either alone or as a mixture of several types. Also, as third component, one may add a small amount of pentaerythritol or other crosslinking compounds. In addition, these polymer components may contain other conventional additives, such as matting agent, coloring agent, weatherability improving agent, oxidation inhibitor, UV absorbent, etc.

In the following, this invention will be explained in detail with reference to application examples. However, this invention is not limited to these application examples. In the application examples, the intrinsic viscosity (η) refers to the viscosity measured at 23°C in a 50:50 (ratio by weight) of phenol:tetrachloroethane mixture.

APPLICATION EXAMPLE 1

Composite spinning was performed using two types of polyethylene terephthalate with different degrees of polymerization and having intrinsic viscosity (η) of 0.54 and 0.74, respectively, to form a filament with side-by-side configuration on the cross section perpendicular to the fiber's axis. Spinning was performed using a 0.8 mm φ x 32 H nozzle at a spinning rate of 40 g/min and at a speed of 750 m/min. Using the method shown in Figure 1, the obtained 480-denier spun yarn was drawn to 3.55-fold at a drawing rate of 500 m/min by means of a hot pin at 85°C and a hot plate at 120°C, and was heat treated continuously at various temperatures and under various tensions. Then, coiling manifestation was performed using the device having rollers (24) ~ (27) shown in Figure 5.

The coiling manifestation was performed under the condition of an overfeeding rate of 40%, with hot air temperature of 170°C in coiling manifestation cylinder (25), and with a spinning speed of 500 m/min for roller (24). Here, the overfeeding rate (F) is defined as follows:
F(%)=[(speed of roller (24)-(speed of roller (26)]/(speed of roller (24)) x 100

The obtained coiling manifested yarns were used for form a cylindrical knitware, and the following evaluation method was adopted to evaluate the coiling property. The results are listed in Table 1:

Evaluation Method	Drawn heat-treated yarn and coiling manifested yarn	Knitware
◎	Yarn with phases of coils deviated from each other completely	Bulging takes place without bumps and dips on the surface
○	Yarn with almost no bundling portions	Bumps and dips appear at various sites, yet bulging takes place
△	Yarn with bundled portions left at various sites	There are many bumps and dips, and the knitware itself is not uniform
×	Yarn with many bundled portions and having overall coil shape	The knitware is thin and no bulging takes place

The other application examples also adopt the same representation.

Table I

No.	Plate (6) Temperature (°C)	Tension (g/d) (between roller (5) and roller (7))	Coiling Property		
			Heat treatment after drawing	Coiling Manifestation	Knitware
1	120	0.005	Yarn cannot be collected due to sagging		
2	120	0.01	○	○	○
3	120	0.03	◎	◎	◎
4	120	0.05	○	○	○
5	120	0.07	△	△	×
6	80	0.03	△	△	△
7	100	0.03	○	○	○
8	140	0.03	○	◎	○
9	180	0.03	○	○	○

For Nos. 2, 3, 4, 7, 8, 9 adopting the method of this invention, pretty knitware products were obtained. For others not using the method of this invention, although the yarn state is good, when knitware is formed, bumps and dips appear on the surface.

APPLICATION EXAMPLE 2

Using the same spun feed yarns as those used in Application Example 1, drawing was performed using the method shown in Figure 2, and heat treatment was performed under various conditions. Then, relaxation heat treatment was performed continuously using the same method as that adopted in Application Example 1. Using the obtained coiling manifested yarns, a knitware sample was prepared, with its coiling property listed in Table II.

Table II.

No.	Roller (15) Temperature (°C)	Tension (g/d) (between roller (12) and roller (13))	Coiling property		
			Heat treatment after drawing	Coiling Manifestation	Knitware
8	120	0.03	○	◎	◎
9	160	0.03	◎	◎	◎
10	190	0.03	○	△	△
11	140	0.07	△	△	×
12	140	0.01	○	○	○

For Nos. 8, 9, 12 adopting the conditions of this invention, pretty knitware products were obtained. For others not adopting the conditions of this invention, defects appear on the knitware.

APPLICATION EXAMPLE 3

Using the same feed yarns as those used in Application Example 1, drawing and heat treatment was performed using the tapered roller shown in Figure 3A in the method shown in Figure 3. Then, coiling manifestation was performed. The drawing and coiling manifestation conditions are the same as those in Application Example 1.

The coiling properties of the obtained coiling manifested yarns were evaluated, with results listed in Table III.

Table III

No.	Roller (18) Temperature (°C)	Taper Outer diameter/inner diameter	Coiling Property		
			Heat treatment after drawing	Coiling Manifestation	Knitware
13	70	10/9	△	×	×
14	110	10/9	○	○	○
15	160	10/9	◎	◎	◎
16	190	10/9	○	○	△
17	120	10/7	Poor stability of yarn path		
18	120	20/19	△	△	×

For Nos. 14 and 15 as embodiment of this invention, good knitware products were obtained.

APPLICATION EXAMPLE 4

Polyester prepared by copolymerization of 7 mol% of dimethyl diadipate with respect to dimethyl terephthalate was used as a component. Polyethylene terephthalate with intrinsic

viscosity [η] of 0.51 that is 0.20 lower than that of said adipic acid copolymerized polyester was used as the other component. These two components were used to spin a bimetal type composite fiber using the same method as in Application Example 1. Then, the obtained yarn was drawn and heat treated using the method shown in Figure 1. Then, coiling manifestation was performed using the device of the portion after roller (24) shown in Figure 5. For the obtained coiling manifested yarns, the coiling property was evaluated, with results listed in Table IV.

Table IV.

No.	Plate (6) Temperature (°C)	Tension (g/d) (between roller (5) and roller (7))	Coiling property		
			Heat treatment after drawing	Coiling manifestation	Knitware
19	80	0.03	△	△	×
20	100	0.03	◎	◎	◎
21	140	0.03	◎	◎	○
22	180	0.03	○	○	○
23	120	0.005	△	△	×
24	120	0.05	○	◎	◎
25	120	0.07	○	△	×

Just as in the case of polyethylene terephthalate, when the method of this invention is adopted (Nos. 20, 21, 22, 24), good yarns and knitware products were obtained.

APPLICATION EXAMPLE 5

The spun feed yarn of polyethylene terephthalate prepared in Application Example 1 was used. Using a pirn at 35°C and a plate at 120(C in a conventional method, the yarn was drawn to 3.55-fold. After the yarn was wound up on a pirn and was set there for a prescribed time, heat treatment was performed using the method shown in Figure 4, followed by coiling manifestation using a conventional method. The tension of yarn between roller (19) and roller (21) was 0.05 g/d, and the temperature of hot plate (20) was at 120(C in the operation.

For the obtained coiling manifested yarn, the coiling property was evaluated, with results listed in Table V.

Table V

No.	Setting time	Coiling property		
		Yarn would up as shown in Figure 5	Coiling manifested yarn	Knitware
26	Right after winding up	◎	◎	◎
27	1 hour later	◎	◎	◎
28	5 hours later	◎	◎	◎
29	1 day later	◎	◎	◎
30	10 days later	◎	◎	◎

For all of the obtained yarns and knitware samples, the quality is good and there is no variation over time.

APPLICATION EXAMPLE 6

The same drawn yarn as that in Application Example 5 was used in this case. As shown in Figure 5, the yarn tension between roller (22) and hot plate (23) at 150°C was kept at 0.03 g/d, and, using coiling manifestation cylinder (25), coiling was manifested continuously at a yarn feeding speed of roller (24) of 500 m/min and overfeeding rate of 40% to obtain a coiling manifested yarn. Drawing and coiling manifestation were performed under the same conditions as in Application Example 1.

For the obtained coiling manifested yarn, the coiling manifestation property was evaluated, with results listed in Table VI.

Table VI.

No.	Setting time	Coiling property	
		Coiling manifested yarn	Knitware
31	Right after winding up	◎	◎
32	5 hours later	◎	◎
33	1 day later	◎	◎

When heat treatment is performed according to the method of this invention, for all of the samples, there is no influence of the setting time, and the disadvantage due to continuous operation is not displayed. As a result, good knitware can be formed.

BRIEF DESCRIPTION OF FIGURES

Figures 1, 2 and 3 illustrate steps of operation for embodiment of this invention. Figures 3A, B and C are side views of roller (18) in Figure 3. Figure 4 is a diagram illustrating the operation when this invention is embodied alone. Figure 5 is a diagram illustrating the

continuous operation [with heat treatment] performed before the later coiling manifestation device.

Figures 6 and 7 illustrate the state of the coiling manifested yarn when this invention is not adopted. Figure 8 illustrates the coiling manifested yarn when treatment is performed under conditions other than those of this invention. Figure 9 is a diagram illustrating the state of the coiling manifested yarn when this invention is embodied.

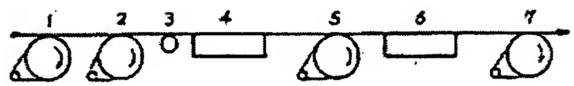

Figure 1

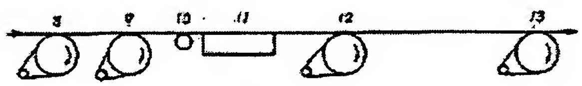

Figure 2

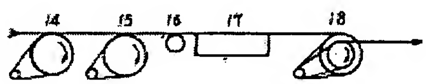

Figure 3

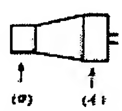

Figure 3A

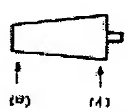

Figure 3B

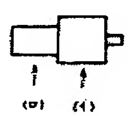

Figure 3C

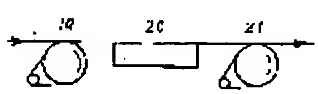

Figure 4

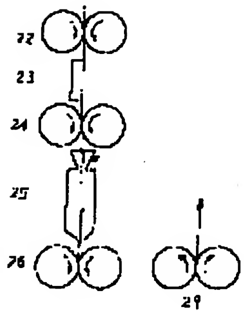

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

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